Biotechnology: An Indian Journal

Review Article | Vol 18 Iss 3

Gigantic Role of Nanobots in Saving Lives

Andrea Janet D'Souza*

Department of Biotechnology, Jain University, Bengaluru, Karnataka, India

***Corresponding author:** Andrea Janet D'Souza, Department of Biotechnology, Jain University, Bengaluru, Karnataka, India; E-mail:andrearhea15@gmail.com

Received: April 22, 2022, Manuscript No. tsbt-22-61597; **Editor assigned:** April 25, 2022, PreQC No. tsbt-22-61597;
Reviewed: May 09, 2022, QC No. tsbt-22-61597; **Revised:** June 21, 2022, Manuscript No. tsbt-22-61597;
Published: June 28, 2022, DOI: 10.37532/0974-7435.22.18.002

Abstract

The current pandemic has shed light on the fact that global health infrastructure needs a considerable upgradation and nanotechnology which is an interdisciplinary field incorporating Physics, Chemistry and Biology seems to have great potential in alleviating global healthcare by targeted drug delivery, nanorobotic surgeries, body surveillance, so on and so forth. Nanobots are nanoscale self-propelled robots which target disease cells with minimum invasiveness, high precision and fewer side-effects. This paper will focus on some breakthroughs of nanotechnology in the field of medical science and the pros and cons of this technology.

***Keywords:** Nanotechnology; Nanobots; Precision; Drug delivery; Breakthroughs; Medical science*

Introduction

The realm of nanotechnology lies between 0.1-100 nanometers and 1 nanometer is one thousand millionth of a meter. However, this miniscule technology is ironically growing larger with each passing day. As the Covid- 19 pandemic brought the world to its knees, the global nanotechnology market is estimated at US$42.2 billion in 2020 and is projected to reach US$70.7 billion by 2026 growing at a (Compound Annual Growth Rate) CAGR of 9.2% over the analysis period. [1]

Among the several applications of nanotechnology in medicine, targeted drug delivery is a frontrunner and the market value has exponentially increased over the last decade. Nanobots can surpass some of the common drawbacks of present day medical science. For instance, with nanobots, painful incisions which require a lot of care and take a lot of time to heal will not be needed. Delicate invasive surgeries like eye surgeries could also be performed with ease and precision. The idea of ingesting a capsule with cameras and biosensors or drinking a milkshake which contains exosomes loaded with therapeutic peptides and could possibly protect one from a Myocardial infarction is no longer science fiction. Nanotechnology is slowly but steadily changing the face of modern medicine.

Literature Review

Richard Feynman's speech "There's plenty of room at the bottom" in 1959 led to the birth of idea of nanotechnology however it was in 1974 that Norio Taniguchi of Tokyo University coined the term "nanotechnology" and is defined it as "nanotechnology mainly consists of processing of separation, consolidation and deformation of materials of materials by 1 atom or 1 molecule" [2] Since the last half century, the field of nanotechnology has progressed through leaps and bounds and has found huge applications in pharmaceutical and healthcare.

Manufacture of nanobots

Citation: Janet D'Souza A. Gigantic role of nanobots in saving lives. Biotrch Ind J. 2022;18(3):002

Nanoscale robotic models are constructed by self-assembly of many tiny components. Efficient acoustic communication techniques and the Lewis algorithm technique for chemical communication are used to program the nanobots in *in vivo* conditions. Glucose in the bloodstream and ambient oxygen can also be drivers of nanobots within the body. [3]

Two approaches to building nanobots: Bottom-up approach which is molecular assembly *i.e.* assembling the nanobot from basic molecules. Top-up approach using current technologies like Micro Electro Mechanical Systems (MEMS) and scaling them down to nanoscale. [4]

Some of the nanobots engineered so far are Respirocytes which are artificial Red Blood Cells (RBCs) capable of carrying oxygen 236 times more than normal RBCs. Microbiovores which are capable of destroying pathogens present inside the human body. Clottocytes help in wound healing by forming a fibrous mesh over the site of injury. Chromallocytes are gene delivery vectors which can help in cell repair by replacing chromosomes [5].

Apart from these, researchers at Aarhus University have designed a synthetic DNA nanopore which will help in diagnostic purposes as a sensor could be inserted into particular diseased cells [6].

Cyborg organoids developed by researchers at Harvard have sensors integrated into them which could send visuals of organ development and even visualise stem cells differentiation into cardiomyocytes. [7] Xenobots or living nanobots are by far the most fascinating nanobots created till date. Made from the stem cells of the frog *Xenopus laevis*, these xenobots can aid in drug delivery and could also heal themselves after a cut [8].

Applications of nanobots in medical science

Body surveillance: Nanobots could continuously monitor pulse rate, blood pressure, SpO_2 levels and blood glucose levels and could even transmit the vitals to a mobile phone and this would be a quantum leap for diagnostics. These wireless nanobots circulating in the bloodstream could also send out warning signals. It could also send out information about the progression of a disease. Swarm intelligence is the concept of using a group of nanobots for disease diagnosis and building strong body defenses against microbes [9].

Nano surgery: The use of nanobots during invasive surgeries could be beneficial at many levels. Firstly, pre and post-operative care will not be much needed as these surgeries will be non-invasive. Secondly, hospital acquired infections have seen a spike in recent times and the use of anti-infective nanosilver which is non-toxic as well as bacteria have still not become resistant against it so it's a safe alternative [10].

Cancer treatment: Nanobots attack only the cancer cells and do not affect the surrounding cells and tissues. So, its high precision makes it a suitable substitute for chemotherapy. The swarming algorithm has also been engineered to treat tumors where many nanobots come together at the site of the tumor and communicate and treat the tumor using radio waves. Nanobots could also help in diagnostic purposes to help locate the exact position of the tumor and the extent of metastasis. Anticancer drugs which have nanoparticles integrated seem to have lesser side effects and can easily penetrate into cells [11]. DNA nanobots can currently identify 12 different kinds of Cancer tumors in humans and have become a ray of hope in curing Cancer [12].

Infertility: Nanobots could improve the specificity and sensitivity of medically assisted reproduction. Motorized spermbots can deliver the sperm to the egg. The use of spermbots would also be a less invasive and cheaper alternative as compared to IVF (*in vitro* Fertilization) or Artificial insemination [13].

Antiviral therapies: Antiviral nanotherapeutics could potentially solve the problem of drug resistance which is another pandemic looming in the shadows. These antiviral nanobots can pass through impermeable barriers and deliver drugs to treat viral infections [14]. Antiviral nanoformulations could be used for sanitizing surfaces, air and even PPE kits. Designing nano-based sensors for the early diagnosis of COVID-19 is also in progress [15].

Neuroscience: Nanobots due to their small size can cross the blood brain barrier and could thus be used to treat brain tumors and perform delicate neural surgeries without having to drill a hole through the skull. Nanobots could also assist people suffering from motor neuron ailments by picking up impulses which would in normal conditions be delivered to the body's motor neurons. They can also be used to deliver drugs which could help in treatment of neurodegenerative diseases and would also improve the efficiency and sensitivity of the regular drug. In Alzheimer's disease, nanoparticles can prevent the aggregation of amyloid beta plaques as well [16].

Cardiac diseases: Multipurpose nanobots could function as stents and open up blocked arteries. This is advantageous as compared to present tools which are bulky and infection prone. Nanotechnology based approaches to help in early diagnosis and treatment of atherosclerotic plaques has been useful. Nanobots can direct and monitor stem cell which helps in repair of heart fibers after a Myocardial infarction [17]. Nanobots have also been engineered to detect calcifications that can lead to heart attacks or strokes. This offers more advantages over traditional methods which fail to detect small plaque deposits. Additionally other method of detection like Angiography is an invasive procedure and CT scans use ionizing radiations which could have dangerous side-effects [18].

Dentistry: Nanobots could be used for orthodontic treatment, treatment of orofacial fractures and making artificial teeth. Nanobots could be left inside the mouth *via* toothpastes or mouthwashes and could take care of oral hygiene by preventing deposition of plaque [19].

Gene therapy: Nanobots have been used to deliver genes to target cell *in vitro* and *in vivo.* It would increase efficiency and reduce cytotoxicity. Diseases associated with gene anomalies like Haemophilia, glioblastoma and autoimmune disorders could also be cured with these nanobots [20].

Drug delivery: Nanobots could be used for targeted drug delivery in order to prevent peripheral tissue damage. Plus, the use of nanobots for drug delivery circumvents the problems of current drug delivery like poor bio viability, low solubility and side effects. This could be implemented for treating infections as well and in this way help solve the looming danger of antimicrobial resistance [21].

Hearing and vision: Diamond nanoparticles implanted in the retina have compensated for damaged photoreceptors and have helped restore lost vision. Nanoparticle based cochlear implants aid in hearing [22].

Prenatal diagnosis: Nanobots could be used in detecting fetal congenital abnormalities as well as assist in trans placental drug delivery. Also nanobots could detect pregnancy complications and even explore and monitor treatments in fetal and neonatal stages [23].

Even more recently, Scientists at Rice University have developed a smart shirt which can monitor heart rate. The shirt was sewed with carbon nanotube fibers and is comfortable to wear and easy to wash as well. This could replace the traditional heart strap monitor and could show readings on our smartphones! [24].

Discussion

Nanoengineers at UC San Diego have designed Covid- 19 vaccine candidates using Cowpea plants and Escherichia coli bacteria to grow Cowpea plant virus and bacteriophage in the form of ball shaped nanoparticles which were harvested and then a tiny piece of the SARS-Cov2 spike protein was attached the surface which would generate an immune response in the body. The interesting characteristic however is that the plant virus and bacteriophage nanoparticles do not require refrigerators for storage and are extremely stable at high temperatures as well [25].

Researchers at University of Arizona created a nanotherapeutic which when incorporated with ICB (Immune Checkpoint Blockade) therapies could eliminate a large portion of clinically difficult to treat late stage metastatic colorectal cancer and melanoma tumors [26].

Scientists at Technical University of Munich have developed hollow DNA based nano-objects which could capture viruses and render them harmless. This has already been tested against Hepatitis B virus and Adenoviruses and scientists believe it could prove successful against Corona viruses and that would be a big breakthrough in the present scenario [27].

In India, researchers have developed an alternative to administer Docetaxel which is a drug to treat breast cancer. Docetaxel is insoluble in water which makes it highly toxic and can have an impact on surrounding organs so administering it through nanomicelles makes it more target specific and kills only the tumor cells without affecting nearby organs.

Advantages and disadvantages of Nanobots

Some of the advantages of using nanobots in medical science are as follows

- Minimal tissue damage

- Less recovery time
- Less post-treatment care
- Continuous monitoring is possible
- Low cost and quick rehabilitation
- Can be guided or programmed only to target specific cells
- Deliver drugs/healthy cells easily to any location inside the body
- Can disassemble and be excreted easily after doing its job
- Some of the drawbacks of using nanobots are as follows
- Owing to its novel shape, size, physical and chemical properties, nanoparticles pose an occupational hazard risk to workers. According to a CDC report, current research aims to assess the toxicity of nanoparticles and scientists are also investigating the interaction between nanoparticles and the biological systems *in vitro*.
- There is also the risk of future developments and self-replication of nanobots
- The risks of the release of nanoparticles into the environment is also being assessed
- With the use of nanobots, the employment opportunities are going to dwindle as palliative care will no longer be needed in most cases.
- Nanobots are also susceptible to being hacked as anyone with the same acoustic frequency can reprogram the bots which could lead to devastating consequences.
- There are certain ethical issues revolving around nanobots, for instance, a nanobots programmer can reprogram the bot to purloin someone's DNA.

Conclusion

Today as we stand at the dawn of a nanotechnological era, it is imperative that patient safety hold paramount importance. Through this paper, we have seen the tremendous potential that nanotechnology has as well as the potential risks associated with it so it is essential that we minimize risks and maximize benefits and that is possible through extensive scientific research and public trust in science which stems from transparency, open discussions and cooperation. With great power comes great responsibility….Nanotechnology is undoubtedly a revolutionary technology which the world will witness in everyday life in the near future but it can have a huge detrimental effect if it falls into the wrong hands so there should be a special encryption method and stringent laws in place to ensure public safety. The concept of Nanotechnology has even been popularized among the masses through movies like The Terminator, Ironman, and GI Joe: The rise of Cobra, to name a few. It is indeed mind boggling to see how nanotechnology can be applied not just in medicine but almost every other field ranging from agriculture to electronics, aerospace to textiles.

Conflict of interest

The author declares that there is no conflict of interest.

References

1. Bayda S, Adeel M, Tuccinardi T, et al. The History of Nanoscience and Nanotechnology: From Chemical Physical Applications to Nanomedicine. Molecules. 2019;25(1):112.
2. Hogg T, Freitas R. Acoustic Communication for Medical Nanorobots. Nano Communication Networks. 2012.
3. Bhat AS. Nanobots: the future of medicine. Int J Manag Eng Sci. 2014. 5(1): 44-49.
4. Manjunath A, Kishore V. The Promising Future in Medicine: Nano robots. Biomed Sci Eng. 2014;2(2):42-47.
5. Thomsen RP, Malle MG, Okholm A, et al. A large size-selective DNA nanopore with sensing applications. Nature communications. 2019;10(1):5655.
6. Li Q, Nan K, Le Floch P, et al. Cyborg Organoids: Implantation of Nanoelectronics *via* Organogenesis for Tissue-Wide Electrophysiology. Nano letters. 2019;19(8):5781–5789.
7. Kriegman S, Blackiston D, Levin M, et al. A scalable pipeline for designing reconfigurable organisms. Proceedings of the National Academy of Sciences. 2020;117(4):1853-1859.
8. Amato P, Masserini M, Mauri G, et al. (2010) Early-Stage Diagnosis of Endogenous Diseases by Swarms of Nanobots: An Applicative Scenario. International Conference on Swarm Intelligence. Springer, Berlin, Heidelberg. 408–415.
9. Singh S, Singh A. Current status of nanomedicine and nanosurgery. Anesthesia, essays and researches. 2013;7(2):237–242.

10. Tripathi R, Kumar A. Application of nanorobotics for cancer treatment. Materials Today: Proceedings. 2018;5(3):9114-9117.
11. Amir Y, Ben-Ishay E, Levner D. et al. Universal computing by DNA origami robots in a living animal. Nature Nanotech. 2014;9:353–357.
12. Remião MH, Segatto NV, Pohlmann A, et al. The Potential of Nanotechnology in Medically Assisted Reproduction. Frontiers in pharmacology. 2018;8:994.
13. Chakravarty M, Vora A. Nanotechnology-based antiviral therapeutics. Drug Deliv Transl Res. 2021;11(3):748–787.
14. Talebian S, Wallace GG, Schroeder A, et al. Nanotechnology-based disinfectants and sensors for SARS-CoV-2. Nat. Nanotechnol. 2020;15:618–621.
15. Ngowi EE, Wang YZ, Qian L, et al. The Application of Nanotechnology for the Diagnosis and Treatment of Brain Diseases and Disorders. Front Bioeng Biotechnol. 2021;9:629832.
16. Wang DK, Rahimi M, Filgueira CS, et al. Nanotechnology applications for cardiovascular disease treatment: Current and future perspectives. Nanomed Nanotechnol Biol Med. 2021;34:102387.
17. Chin D, Wang J, Plotkin A, et al. Hydroxyapatite-binding micelles for the detection of vascular calcification in atherosclerosis. J Mater Chem. 2019;7(41):6449.
18. Ozak ST, Ozkan P. Nanotechnology and dentistry. Eur J Dent. 2013;7(1):145–151.
19. Chen J, Guo Z, Tian H, et al. Production and clinical development of nanoparticles for gene delivery. Methods Clin Dev. 2016;3:16023.
20. Patra JK, Das G, Fraceto LF, et al. Nano based drug delivery systems: recent developments and future prospects. J Nanobiotechnol. 2018;16(1):71.
21. Türk V, Kaiser C, Schaller S, et al. Invisible but tangible? Societal Opportunities and risks of Nanotechnologies. J Clean Prod. 2008.
22. Vidanapathirana AK (2014) Use of Nanotechnology in Pregnancy. In: Bhushan B. (eds) Encyclopedia of Nanotechnology. Springer, Dordrecht.
23. Taylor LW, Williams SM, Yan JS, et al. Washable, Sewable, All-Carbon Electrodes and Signal Wires for Electronic Clothing. Nano Letters. 2021.
24. Rivera O, Shin M, Chen A, Beiss V, et al. Trivalent Subunit Vaccine Candidates for COVID-19 and Their Delivery Devices. J Am Chem Soc. 2021.
25. Wang Z, Chen J, Han W, et al. Immunogenic camptothesome nanovesicles comprising sphingomyelin-derived camptothecin bilayers for safe and synergistic cancer immunochemotherapy. Nature Nanotechnol. 2021.
26. Sigl C, Engelen W, Sachenbacher K, et al. Programmable icosahedral shell system for virus trapping. Nature Materials. 2021.
27. Dhar S. With nanotechnology, scientists triple efficacy of breast cancer. The Times of India. 2021.